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PHALANGODIDAE FROM CAVES
IN THE SIERRA NEVADA (CALIFORNIA)
WITH A REDESCRIPTION OF THE TYPE GENUS
(Opiliones:Phalangodidae)

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Many of the small limestone caves in the Mother Lode district of the Sierra Nevada possess a varied biota which includes a distinctive genus of laniatorid harvestmen. This group has previously been known only by one species, *Banksula californica* (Banks) which was collected in Alabaster Cave, El Dorado County, California at the turn of the century. Several new species in the genus *Banksula* were collected during an investigation of Sierra Nevada caves with the San Francisco Bay Chapter of the National Speleological Society.

It is now apparent that the genus *Banksula* is entirely confined to caves even though all but one species possess eyes. The only laniatorid opilionids found on the ground in the Mother Lode district are in an unrelated genus of Phalangodidae. This surface-inhabiting genus does include one cavernicolous example in the Sierra Nevada (*Sitalcina cloughensis* Briggs, 1967), but it is found south of the Mother Lode district in a different limestone formation. In spite of broad separation of deposits of Mother Lode (Calaveras) limestone by deep river valleys the allopatric populations of *Banksula* are morphologically similar. This phenomenon of a regional population of allopatric cave

laniatorids being related to each other but unrelated to the regional population of surface laniatorids exists in several parts of the United States and elsewhere and will be discussed in a future paper.

The Mother Lode caves are found in small limestone outcrops and are unprotected from various destructive types of human use. The type species, *Banksula californica*, is only known from Alabaster Cave. From the time Alabaster Cave was partially destroyed by quarrying no further specimens have been found, and the species may be extinct. Another cave, McLean's Cave, is important because among other organisms it contains sympatric species of *Banksula*. This cave will be flooded by a new dam on the Stanislaus River. Several caves, particularly Moaning Cave, are threatened by "improvements" for recreational use.

Several authors have placed *Banksula californica* in the genus *Phalangodes*. The genus *Phalangodes* has long been the recipient of a variety of unrelated species from Europe, United States, and the Carribean. The type species, *Phalangodes armata* Tellkamp, occurs in the Mammoth Caves of the state of Kentucky. An examination of this and related species indicates that *Phalangodes* is restricted to the southeastern United States, possibly limited to caves. To help clarify the morphology of both this genus and Phalangodidae as a whole, redescription of *Phalangodes* will be given based on specimens from Mammoth Cave and nearby Bypass Cave.

During this study it was found desirable to expand the folded velum of the opilionid penis. This was accomplished by brief treatment with 10 percent KOH as is done with the palpi of male spiders. Such a procedure is necessary for a complete description of the genitalia of most male harvestmen in the superfamily Gonyleptoidea (Oncopodoidea).

All types collected in this study are deposited in the collections of the California Academy of Sciences.

PHALANGODES Tellkamp, 1844

Fused segments of scute not delineated by grooves, first segment without a median line. Eye tubercle small, unarmed, clearly separated from anterior margin of scute. Labial processes visible between, but not anterior to, endites of second coxae. Spiracles visible. Sternum narrow, broadening beneath operculum. Tergites reduced, lateral sclerites present. Tarsi of third and fourth legs without scopulae and with simple untoothed double claws. Distitarsi of first leg with two segments, of second with three. Tarsi of first legs with four or five segments. Palpal tarsi with four major lateral spines, femur without dorsal spines. Male with ventral projections on endites of second coxae. Penis with apical process (dorsal plate?) on narrow, unhinged aedeagus; ventral plate bifurcate. Juvenile with large aroleurum on hind claws.

TYPE SPECIES. *Phalangodes armata* Tellkamp (see figs. 1-7).

SPECIMENS EXAMINED. Kentucky: Mammoth Cave, 3 January 1931, H. Dietrich; Bypass Cave, near Bowling Green, Warren County, 31 August 1967, S. Peck and A. Fiske.

BANKSULA Roewer, 1949

Fused segments of scute weakly delineated by grooves, first segment without a medial line. Eye tubercle of normal size, unarmed, clearly separated from anterior margin of scute. Labial processes project anterior to endites of second coxae. Spiracles visible. Sternum narrow, broadening beneath operculum. Tergites of normal size, lateral sclerites present. Tarsi of third and fourth legs without scopulae and with simple untoothed double claws. Distitarsi of first leg with two segments, of second with three. Tarsi of first legs with four segments. Palpal tarsi with four major lateral spines, femur with six to eight dorsal spines. Males without ventral projections on endites. Penis without apical process on aedeagus, hinged aedeagus and dorsal plate expand above ventral plate, dorsal and ventral plates bifurcate. Juveniles with large arolean on hind claws.

TYPE SPECIES. *Scotolemon californicus* Banks.

Key to the Males of *Banksula*

- 1. Operculum small, posterior margin continuous with posterior margin of fourth coxae; apex of aedeagus not enclosed in sheath..... 2
Operculum large, posterior margin behind posterior margin of fourth coxae; apex of aedeagus enclosed in sheath..... 4
- 2. Without corneas and retinae.....
..... *Banksula californica* (Banks)
With corneas and part or all of retinae..... 3
- 3. Second endites with a concave ectal margin of constant radius..... *Banksula galilei*, new species
Second endites with an angular invagination of the ectal margin, interior apex close to posterior margin..... *Banksula tuolumne*, new species
- 4. Aedeagus and enclosing sheath held within bifurcate dorsal plate... *Banksula grahamsi*, new species
Aedeagus and enclosing sheath folds anterior to recurved prongs of dorsal plate.....
..... *Banksula melones*, new species

Banksula californica (Banks).
(Figures 8-11.)

Scotolemon californicus Banks, 1900, J. N. Y. Entomol. Soc., vol. 10, p. 200; 1901, Amer. Natur., vol. 35, p. 672; 1904, Proc. Calif. Acad. Sci., ser. 3, vol. 3, p. 363.

Phalangodes californica, Roewer, 1912, Arch. Naturgesch., vol. 78A, fasc. 3, p. 142; 1923, Die Weberknechte der Erde, p. 105.

Banksula californica, Roewer, 1949, Senckenbergiana, vol. 30, p. 33.

LECTOTYPE. Female. Body length 2.06mm. Scute length 1.25mm. Scute width 1.33mm. Eye tubercle length 0.21mm. Eye tubercle width 0.38mm.

	I	II	III	IV	Palpus
Trochanter	0.1mm.	0.2mm.	0.2mm.	0.2mm.	0.2mm.
Femur	1.1	1.4	1.1	1.4	0.7
Patella	0.3	0.4	0.3	0.4	0.4
Tibia	0.8	1.3	0.9	1.3	0.6
Metatarsus	0.8	1.0	1.0	1.3	-
Tarsus	0.8	1.5	0.8	1.1	0.8
Total	<u>3.9mm.</u>	<u>5.8mm.</u>	<u>4.3mm.</u>	<u>5.7mm.</u>	<u>2.7mm.</u>

Scute with cheliceral sockets, not tuberculate, segmentation not apparent. Eye tubercle subconical, tuberculate, retinæ absent, corneas very small or absent. Tergites with row of tubercles at posterior margins. Second endites large, setose, project anteriorly as triangular lobes. Labial processes project anterior to second endites. Operculum small, subtriangular, posterior margin adjacent to mesal apex of posterior margin of fourth coxae.

Chelicerae setose, basal segments with ectal spur.

Palpi with six major spines on dorsum of femora.

Tarsal formula 4-6-5-6.

Color of body concolorous yellow.

PARALECTOTYPE. Male. Body length 1.88mm. Scute length 1.41mm. Scute width 1.36mm. Eye tubercle length 0.31mm. Eye tubercle width 0.38mm.

	I	II	III	IV	Palpus
Trochanter	0.2mm.	0.2mm.	0.2mm.	0.2mm.	0.3mm.
Femur	1.1	1.6	1.3	1.4	0.9
Patella	0.4	0.5	0.3	0.4	0.6
Tibia	-	0.4	1.0	1.4	0.7
Metatarsus	-	-	1.1	1.4	-
Tarsus	-	-	0.9	0.9	0.7
Total	<u>-</u>	<u>-</u>	<u>4.8mm.</u>	<u>5.7mm.</u>	<u>3.2mm.</u>

Similar to female but with narrower operculum and more robust palpal femur. Penis with bifurcate ventral plate bearing setae on recurved distal processes. Articulated dorsal plate retracted anterad, bifurcate with acute distal processes. Base of dorsal plate smooth. Aedeagus unsheathed at apex, unfolds anterior to dorsal plate when turgid.

TYPE DESIGNATIONS. Lectotype female, paralectotype male and paralectotype females from the Nathan Banks type series in the collection of the Harvard Museum of Comparative Zoology. Types are from Alabaster Cave, El Dorado County, California.

REMARKS. A thorough search has failed to locate specimens in the remainder of Alabaster Cave. The male paralectotype does not have complete first and second legs.

Banksula tuolumne Briggs, new species.
(Figures 12-17.)

HOLOTYPE. Male. Body length 1.80mm. Scute length 1.33mm. Scute width 1.36mm. Eye tubercle length 0.28mm. Eye tubercle width 0.39mm.

	I	II	III	IV	Palpus
Trochanter	0.2mm.	0.2mm.	0.2mm.	0.2mm.	0.2mm.
Femur	1.0	1.4	1.2	1.1	0.9
Patella	0.4	0.5	0.3	0.5	0.5
Tibia	0.9	1.4	1.1	1.5	0.6
Metatarsus	1.0	1.3	1.2	1.5	-
Tarsus	0.9	1.7	1.0	1.3	0.8
Total	4.4mm.	6.5mm.	5.0mm.	6.1mm.	3.0mm.

Scute with cheliceral sockets, moderately tuberculate, segmentation delineated by rows of tubercles. Eye tubercle subconical, tuberculate, with small corneas and depigmented retinæ. Tergites with row of tubercles. Second endites large, setose, narrowest behind midpoint at deep angle. Spatulate labial processes project anterior to second endites. Operculum small, subtriangular, posterior margin adjacent to mesal apex of posterior margin of fourth coxae.

Chelicerae setose, basal segments with ectal spur.

Palpi with eight major spines on dorsum of femora.

Tarsal formula 4-6-5-6.

Color of body concolorous orange-yellow.

Penis with bifurcate ventral plate bearing setae on recurved distal processes. Articulated dorsal plate bifurcate with acute distal processes arched mesodorsad. Dorsal plate retracted posterad. Base of dorsal plate smooth. Aedeagus unsheathed at apex, unfolds anterior to dorsal plate when turgid.

ALLOTYPE. Female. Similar to male.

TYPE SPECIMENS. Holotype male and allotype female: under wood in lower level, Tuolumne Crystal Cave, near Tuolumne, Tuolumne County, California, 22 February 1969, T. Briggs. Nine paratypes: same locality, 22 February 1969, T. Briggs.

Banksula galilei Briggs, new species.
(Figures 18-22.)

HOLOTYPE. Male. Body length 1.62mm. Scute length 1.12mm. Scute width 1.12mm. Eye tubercle length 0.20mm. Eye tubercle width 0.29mm.

	I	II	III	IV	Palpus
Trochanter	0.2mm.	0.2mm.	0.2mm.	0.2mm.	0.2mm.
Femur	1.0	1.1	1.0	1.1	0.7
Patella	0.3	0.4	0.3	0.4	0.5
Tibia	0.7	1.1	0.9	1.1	0.5
Metatarsus	0.8	0.9	1.0	1.1	-
Tarsus	0.8	1.2	0.8	1.0	0.3
Total	3.8mm.	4.9mm.	4.2mm.	4.9mm.	2.2mm.

Scute with cheliceral sockets, lightly tuberculate, segmentation delineated by rows of small tubercles. Eye tubercle subconical, tuberculate, with small corneas and retinae. Tergites with row of tubercles. Second endites large, setose, narrowest at midpoint, ectal margin concave. Spatulate labial processes project anterior to second endites. Operculum small, apically rounded, posterior margin adjacent to mesal apex of posterior margin of fourth coxae.

Chelicerae setose, basal segments with ectal spur.

Palpi with seven major spines on dorsum of femora.

Tarsal formula 4-6-5-6.

Color of body concolorous orange-yellow.

Penis with bifurcate ventral plate bearing setae on recurved distal processes. Articulated dorsal plate bifurcate with acute distal prongs arched dorsad. Basal stem of dorsal plate smooth. Aedeagus unsheathed at apex, unfolds anterior to dorsal plate when turgid.

ALLOTYPE. Female. Similar to male but larger in overall size.

TYPE SPECIMENS. Holotype male: under breakdown in pit room, Lime Rock Caves, near Auburn, Placer County, California, 21 December 1966, V. F. Lee and T. Briggs. Allotype female: same locality, 2 June 1966, A. Jung, K. Hom, and T. Briggs. Five paratypes: same locality, 21 December and 2 June 1966, A. Jung, K. Hom, V. F. Lee, and T. Briggs. Two paratypes: Lime Rock Cave #3, same locality, 2 June 1966, K. Hom and T. Briggs.

Banksula grahami Briggs, new species.
(Figures 23-26.)

HOLOTYPE. Male. Total body length 1.63mm. Scute length 1.20mm. Scute width 1.23mm. Length of eye tubercle 0.22mm. Width of eye tubercle 0.30mm.

	I	II	III	IV	Palpus
Trochanter	0.2mm.	0.2mm.	0.2mm.	0.2mm.	0.2mm.
Femur	0.9	1.3	1.1	1.3	0.7
Patella	0.4	0.4	0.3	0.4	0.4
Tibia	0.7	1.1	0.8	1.2	0.6
Metatarsus	0.7	1.0	1.0	1.2	-
Tarsus	0.8	1.7	0.8	1.0	0.7
Total	3.7mm.	5.7mm.	4.2mm.	5.3mm.	2.6mm.

Scute with cheliceral sockets, segmentation delineated by small tubercles. Eye tubercle subconical, slightly tuberculate, with small corneas and retinae. Tergites with row of small tubercles. Second endites setose, mesally broad and rounded. Labial processes spatulate, project anterior to second endites. Operculum large, posterior margin posterior to mesocaudal apex of hind coxae.

Chelicerae with ectal spur on basal segments.

Palpi with six major spines on dorsum of femora.

Tarsal formula 4-6-5-6.

Color of body concolorous yellow-orange.

Penis with bifurcate ventral plate bearing setae on recurved distal processes. Articulated dorsal plate bifurcate, base broad and slightly wrinkled. Apex of aedeagus enclosed in rounded sheath and held within distal portion of dorsal plate.

ALLOTYPE. Female. Similar to male. Operculum slightly thickened along anterior margin.

TYPE SPECIMENS. Holotype male and allotype female: under wood and rocks, Moaning Cave, near Vallecitos, Calaveras County, California, 22 December 1968, T. Briggs. Two paratypes: Moaning Cave, (56°F.), near Vallecitos, Calaveras County, California, 22 August 1963, R. E. Graham. Two paratypes: same locality, 22 December 1968, T. Briggs.

OTHER LOCALITIES. Tuolumne County: under rocks, Crystal Palace Cave, near Columbia, 4 November 1967, V. F. Lee and T. Briggs; under talus in main passage, McLean's Cave, near Columbia, 13 May 1967, T. Briggs; same locality, 24 June 1967, K. Hom and T. Briggs.

REMARKS. Some specimens have as many as eight dorsal spines on the palpal femur. Seven segments are found on the second or fourth tarsus of some individuals.

Banksula melones Briggs, new species.
(Figures 27-28.)

HOLOTYPE. Male. Body length 2.22mm. Scute length 1.33mm. Scute width 1.40mm. Eye tubercle length 0.39mm. Eye tubercle width 0.41mm.

	I	II	III	IV	Palpus
Trochanter	0.2mm.	0.2mm.	0.2mm.	0.3mm.	0.2mm.
Femur	1.1	1.5	1.1	1.3	0.9
Patella	0.4	0.5	0.3	0.5	0.5
Tibia	0.8	1.3	1.0	1.3	0.6
Metatarsus	0.9	1.1	1.1	1.3	-
Tarsus	0.9	1.7	0.9	1.1	0.8
Total	4.3mm.	6.3mm.	4.6mm.	5.8mm.	3.0mm.

Scute with cheliceral sockets, segmentation delineated by small tubercles. Eye tubercle subconical, slightly tuberculate; with large, well developed eyes. Tergites with row marginal tubercles. Second endites setose, subtriangular. Labial processes project distoventrally from second endites. Operculum large, posterior margin posterior to mesocaudal apex of hind coxae.

Chelicerae with ectal spur on basal segments.

Palpi robust, eight major spines on dorsum of femora.

Tarsal formula 4-6-5-6.

Color of body concolorous yellow-orange.

Penis with shallow bifurcation of ventral plate, ectal setae present on recurved distal processes. Articulated dorsal plate bifurcate, base broad and corrugated. Apex of aedeagus in truncate sheath which unfolds anterior to acute, recurved distal processes of dorsal plate.

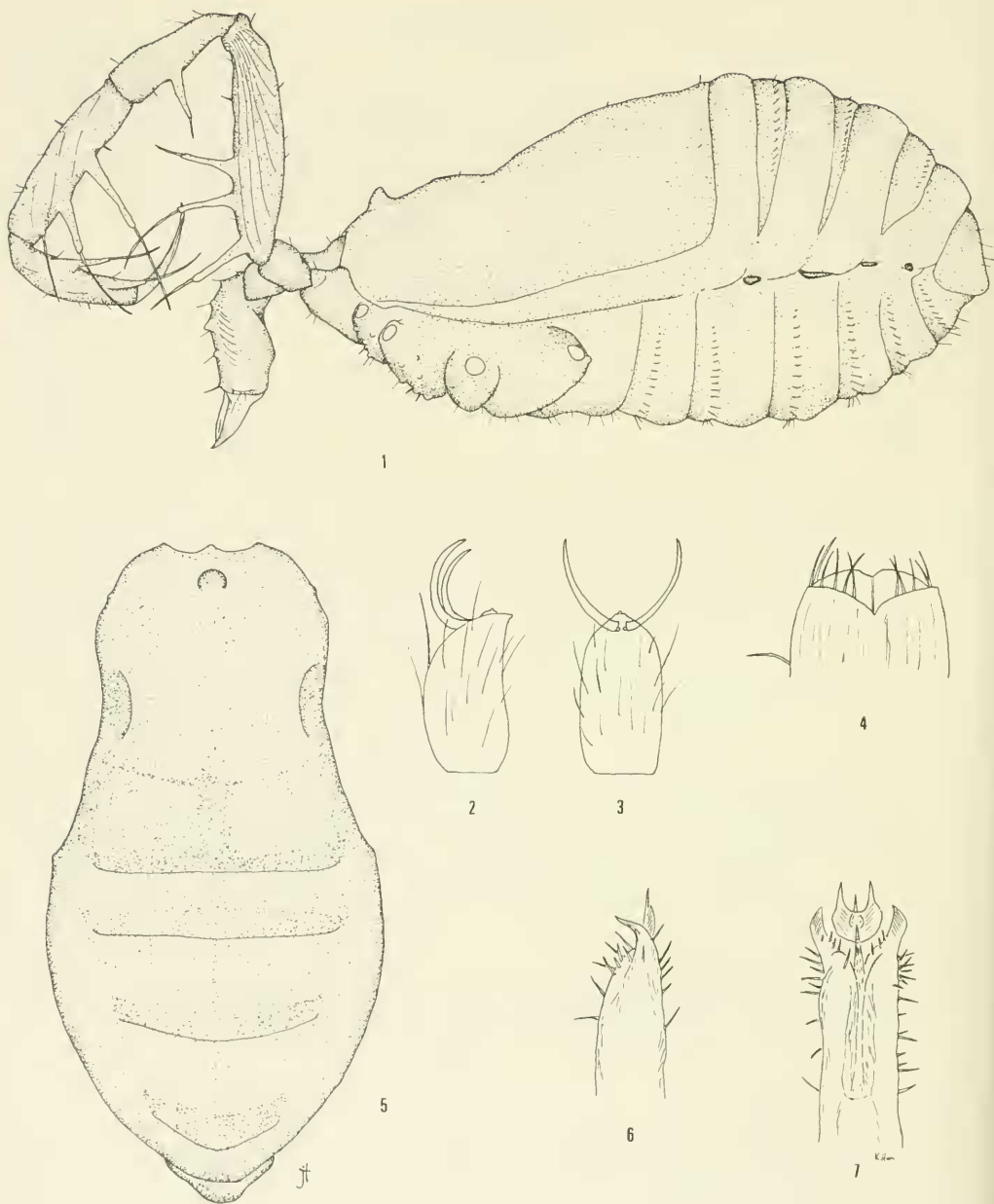
ALLOTYPE. Female. Similar to male.

TYPE SPECIMENS. Holotype male and allotype female: middle level, Quarry Cave, near Columbia, Tuolumne County, California, 24 May 1969, G. Leong, W. Rauscher, and T. Briggs.

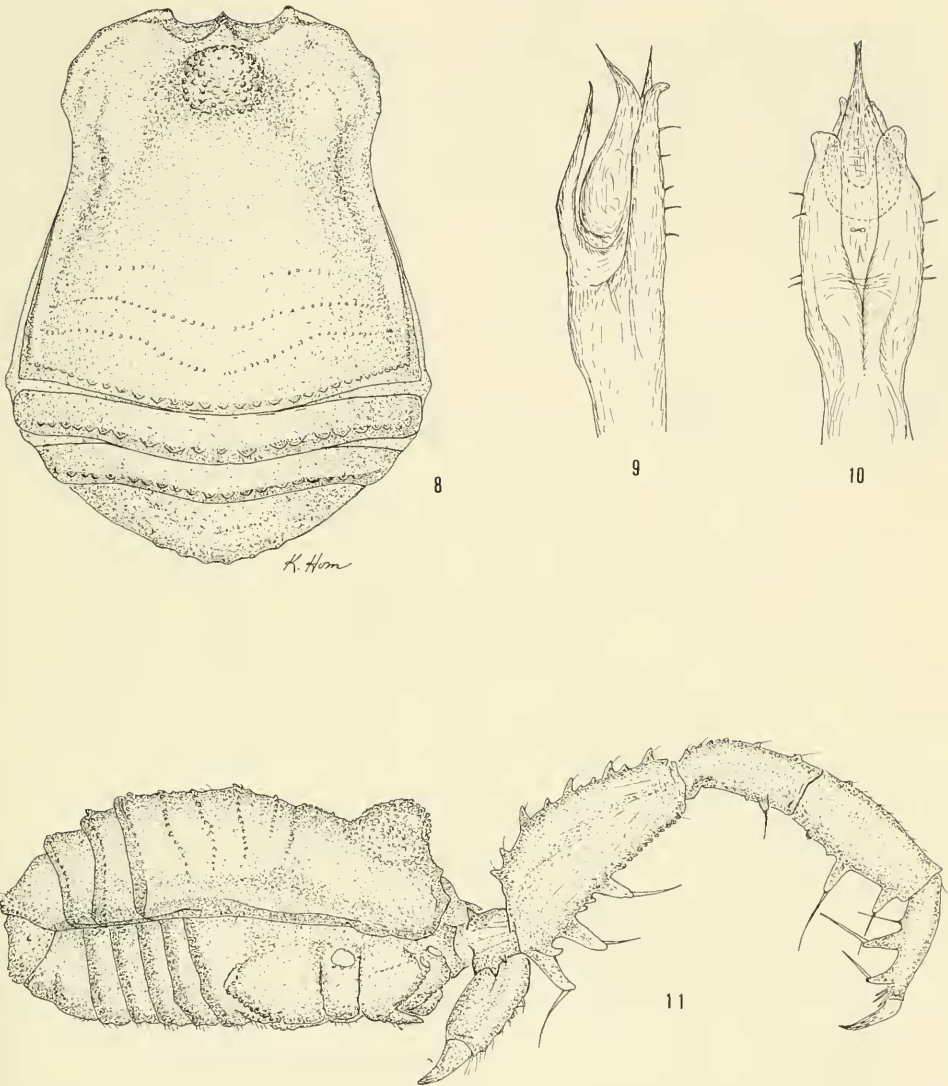
OTHER LOCALITIES. Tuolumne County: under talus in main passage, McLean's Cave, near Columbia, 13 May 1967, V. F. Lee and T. Briggs; same locality, 24 June 1967, K. Hom and T. Briggs; same locality, 17 June 1967, V. F. Lee and T. Briggs.

ACKNOWLEDGMENTS

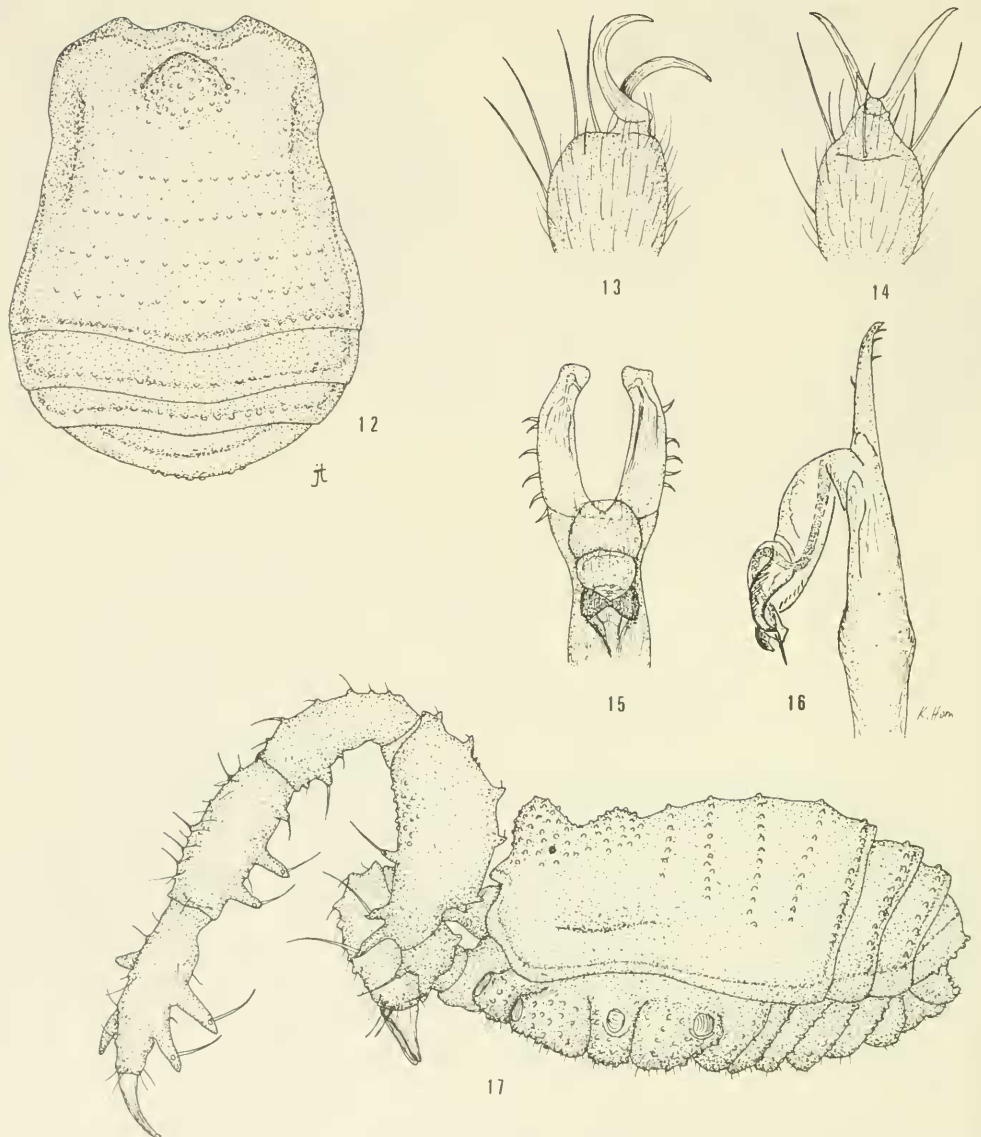
The author wishes to thank Herbert W. Levi of the Harvard Museum of Comparative Zoology for the loan of the type of *Banksula californica*, Willis J. Gertsch, John A. L. Cooke, and Stewart B. Peck for the loan of specimens of *Phalangodes armata* and Richard E. Graham for specimens of *Banksula* from Moaning Cave. Drawings were made by Jack Tom and Kevin Hom. Much of the field investigation was done by Kevin Hom, Albert Jung and Vincent F. Lee while they were science students at Galileo High School.



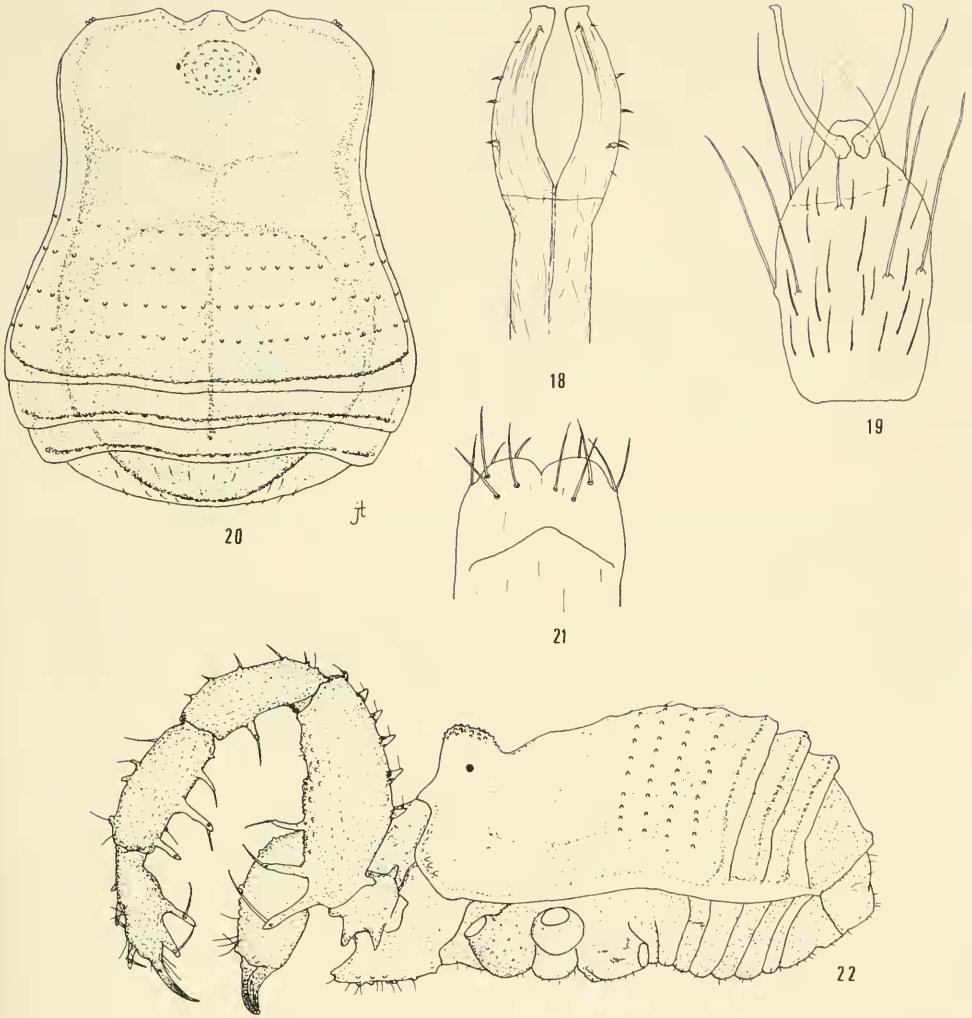
FIGURES 1-7. *Phalangodes armata* Tellkamp. FIGURE 1. Lateral view of female. FIGURES 2-3. Claws of hind tarsus. FIGURE 4. Ovipositor. FIGURE 5. Dorsal view of female. FIGURES 6-7. Lateral and ventral views of penis.



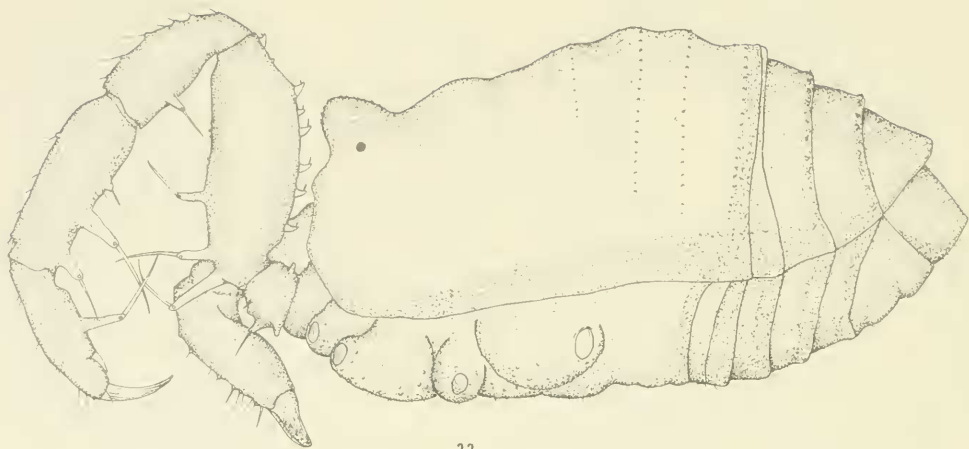
FIGURES 8-11. *Banksula californica* (Banks). FIGURE 8. Dorsal view of lectotype. FIGURES 9-10. Lateral and ventral views of penis. FIGURE 11. Lateral view of lectotype.



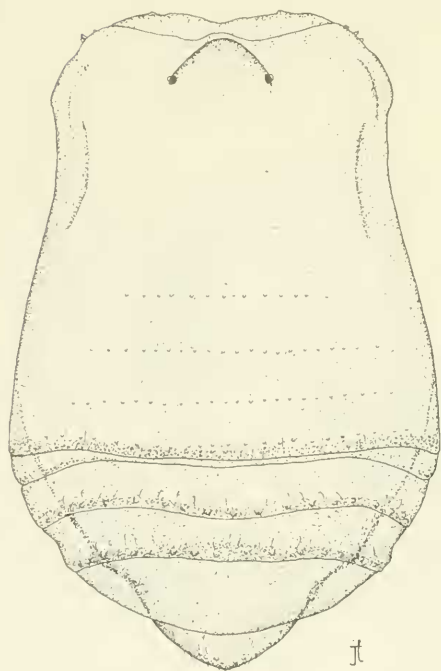
FIGURES 12-17. *Banksula tuolumne* Briggs, new species.
FIGURE 12. Dorsal view of male. FIGURES 13-14. Claws of hind tarsus. FIGURES 15-16. Ventral and lateral views of penis. FIGURE 17. Lateral view of male.



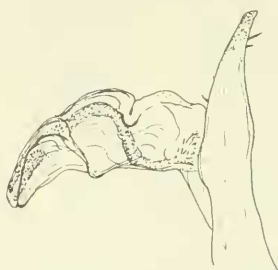
FIGURES 18-22. *Banksula galilei* Briggs, new species.
FIGURE 18. Ventral view of penis. FIGURE 19. Claws of
hind tarsus. FIGURE 20. Dorsal view of male. FIGURE 21.
Ovipositor. FIGURE 22. Lateral view of male.



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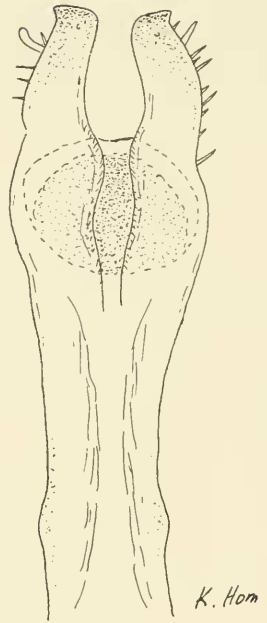


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FIGURES 23-26. *Banksula grahami* Briggs, new species.
FIGURE 23. Lateral view of male. FIGURES 24-25. Lateral
and ventral views of penis. FIGURE 26. Dorsal view of male.



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FIGURES 27-28. Lateral and ventral views of the penis of *Banksula melones* Briggs, new species.